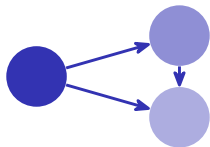


Organic Synthesis

A-Level Chemistry ■ Topic 21

A-Level Chemistry



What we will cover

- 1 Identifying functional groups
- 2 The reaction map
- 3 Planning a route



built in many steps



Identifying functional groups

Each test points to one **functional group** :

- bromine water decolourised → alkene
- AgNO_3 precipitate → halogenoalkane
- dichromate orange → green → alcohol
- fizz with carbonate → carboxylic acid

Identifying functional groups, in detail

add this	you see	functional group
bromine water	orange → colourless	C=C (alkene)
silver nitrate	a precipitate forms	halogenoalkane
acidified $\text{K}_2\text{Cr}_2\text{O}_7$	orange → green	1°/2° alcohol
2,4-DNPH	orange precipitate	aldehyde / ketone
a carbonate	fizzes (CO_2 given off)	carboxylic acid

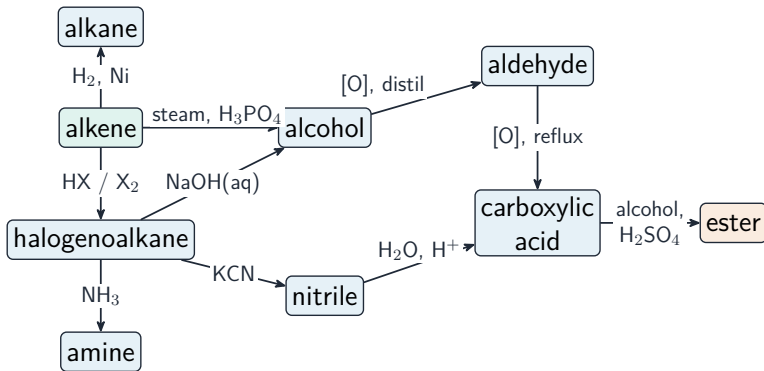
The standard identification tests: each reagent gives a characteristic observation that points to one functional group

The reaction map

Each arrow turns one functional group into another.

Learn it as a **map** you can travel around. **KCN** is the only AS step that **adds a carbon**.

The reaction map, in detail



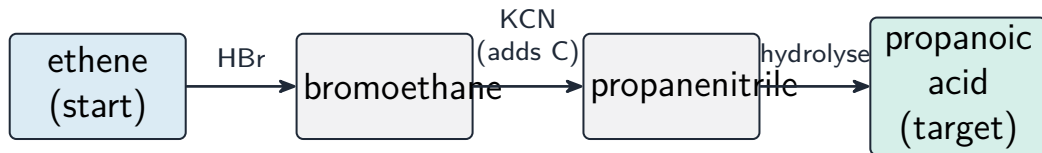
Each arrow turns one functional group into another.

Planning a route

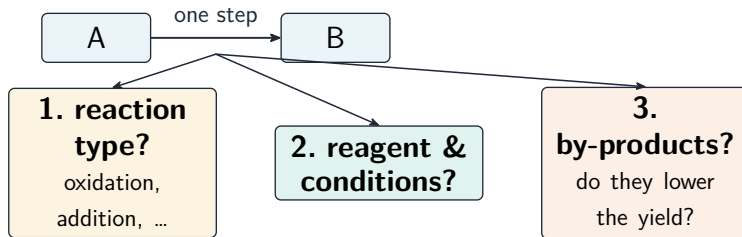
To devise a **synthetic route** :

- compare target vs start (group? carbons?)
- work **backwards**, one reaction at a time
- write each step's **reagent** & conditions

plan backwards from the target



Analysing a route



e.g. a halogenoalkane $\rightarrow$ amine also makes further-substituted amines, so the simple-amine yield is low

For every step in a given route, ask its reaction type, reagent and by-products

Analysing a route, continued

name the reaction type at each step

oxidation	loses electrons / gains O or loses H (e.g. alcohol $\rightarrow$ acid)
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reduction	gains electrons / loses O or gains H
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substitution	one atom or group swaps for another
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addition	two molecules join; a C=C double bond opens
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elimination	a small molecule is removed; a C=C forms
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also give the **reagent** for each step, and watch for **by-products** (e.g. amines over-substitute)

Name the reaction type at each step: oxidation, reduction, substitution, addition or elimination

Planning a synthesis backwards

what this topic adds

no new reactions – it asks you to **join up** the ones you already know

1. compare

count the carbons in target and starting material, and note which **functional groups** each has

2. work backwards

ask what could have made the target in one step

3. repeat

ask the same of that intermediate, **until you reach the starting material**

the carbon-changing steps

KCN adds one carbon; hydrolysis or reduction of the nitrile keeps it

the group ladder

alcohol → **aldehyde** → carboxylic acid → **ester** ;
halogenoalkane → **amine** or nitrile

Working **backwards** from the target is faster than forwards from the start, because the target has only a few possible immediate precursors.

Exam tips

- Learn the **reagents and conditions** for each conversion – that is exactly what synthesis questions test.
- Plan multi-step routes by functional group and watch the **carbon count** (KCN adds one carbon).
- Choose the **shortest valid route** and state every reagent and condition.



Worked example – planning a synthesis

Suggest a two-step route from 1-bromopropane to propanoic acid, with reagents and conditions.

- Count the carbons **first**: 3 in, 3 out – so no carbon-adding step is needed.
- Step 1: reflux with **aqueous NaOH** $\Rightarrow$ nucleophilic substitution $\Rightarrow$ propan-1-ol.
- Step 2: reflux with **acidified $K_2Cr_2O_7$** $\Rightarrow$ oxidation $\Rightarrow$ **propanoic acid**.
- Reflux (not distil) in step 2, or you stop at propanal.

Count carbons **first**. Same number $\Rightarrow$ substitute and oxidise. One **more** carbon $\Rightarrow$ go via the nitrile (KCN in ethanol), then hydrolyse.

Topic 21 – key takeaways

1

Tests

each reagent identifies one functional group

2

Map

arrows convert one group to another

3

Plan backwards

from the target to the start

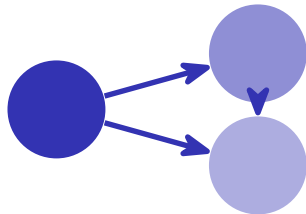
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Add a carbon

the KCN step is the key

Check yourself

- 1 What test confirms a carboxylic acid?
- 2 Which way should you plan a synthesis?
- 3 Which reagent lengthens the carbon chain?
- 4 What must you state for each step?



Answers 1. fizz (CO_2) with a carbonate 2. backwards from the target 3. KCN
4. the reagent and conditions